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WO 98/16764 A1 US 5913678 A US 5799491 A

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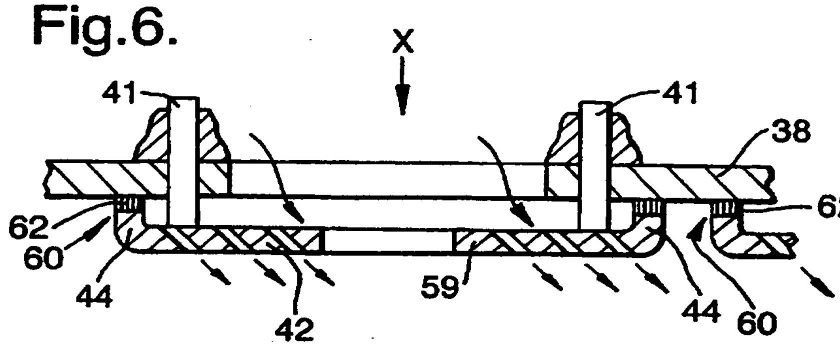
(54) Abstract Title
Combustor wall tile

(57) A wall element (42) for use in a gas turbine engine combustor is provided with deformable seal means in the form of a brush seal (60) for sealing against the outer wall (38) of the wall structure in use. The brush seal may include filaments of metal which may be cast integrally with the remainder of the tile (40).

Fig.6.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

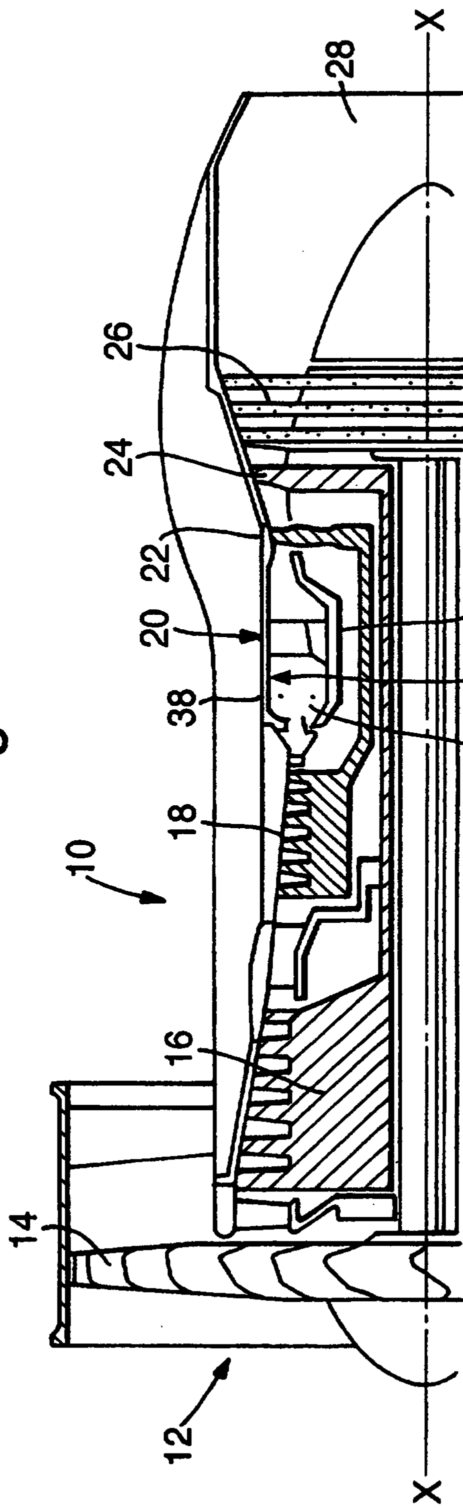
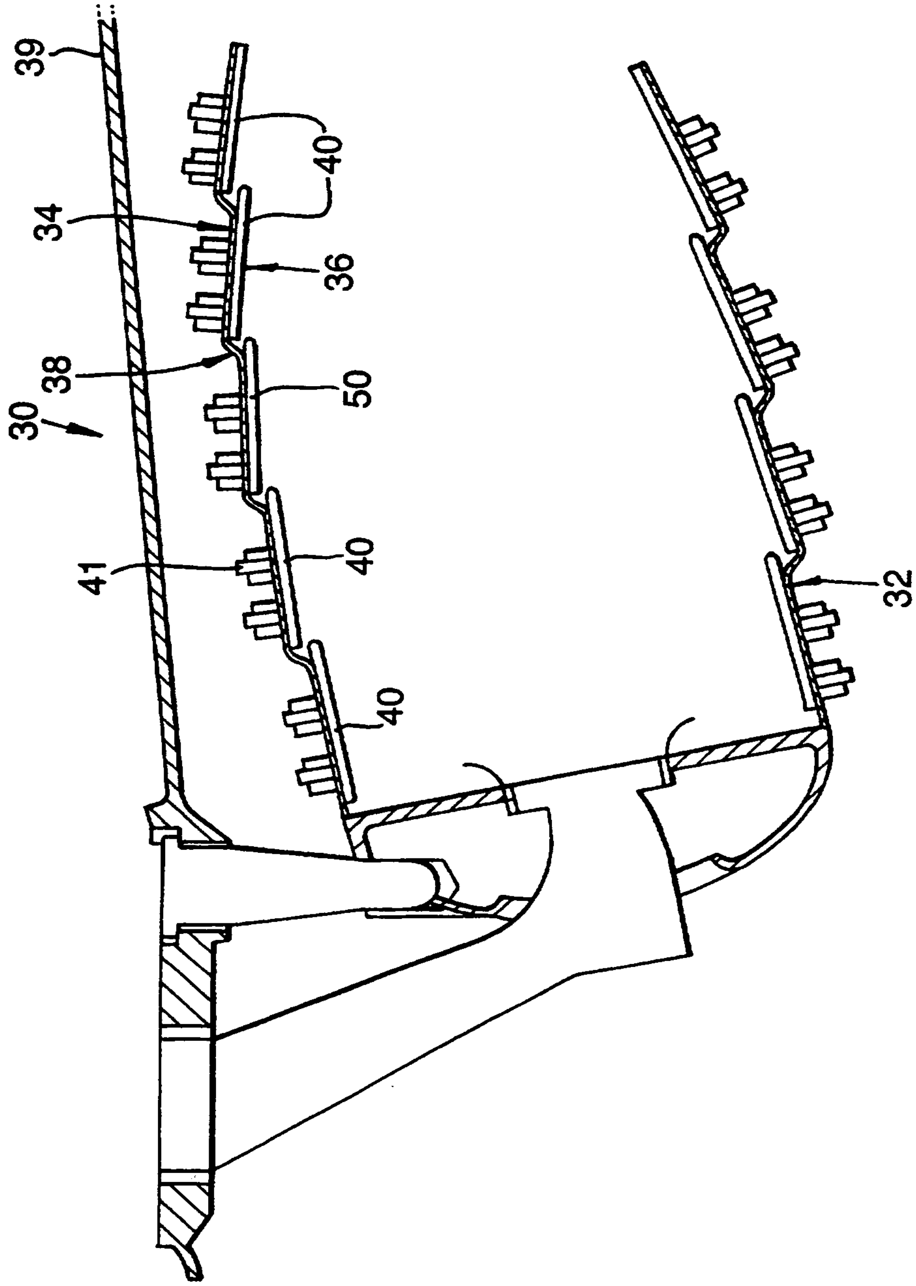


Fig.1.

Fig.2A.



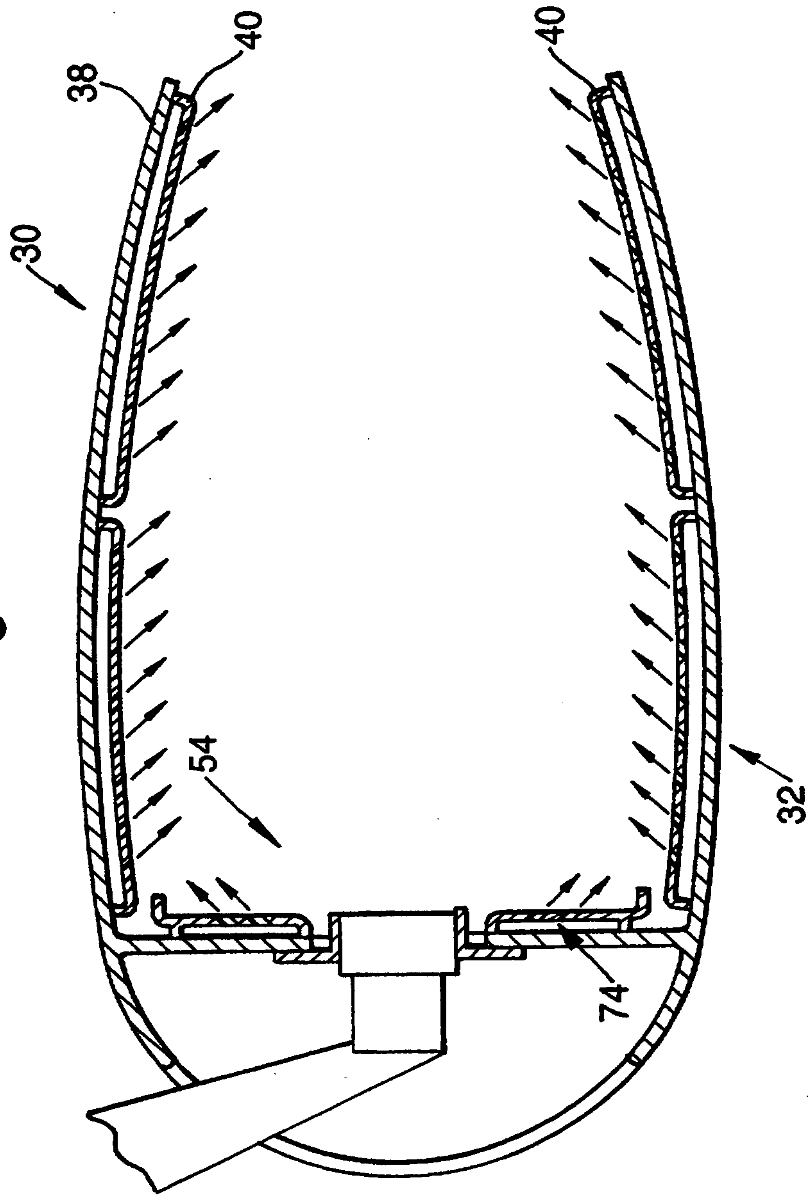


Fig.2B.

Fig.3.

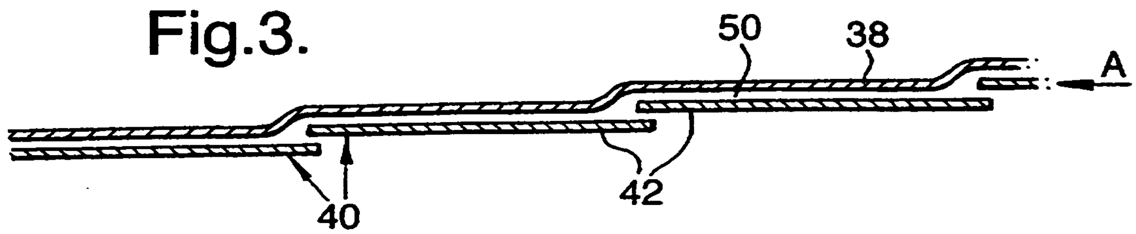


Fig.4.

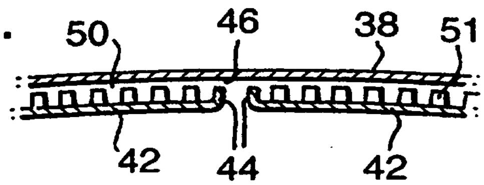


Fig.5.

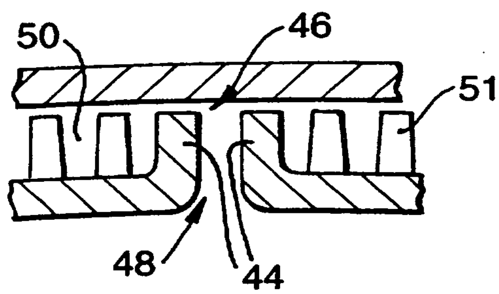


Fig.6.

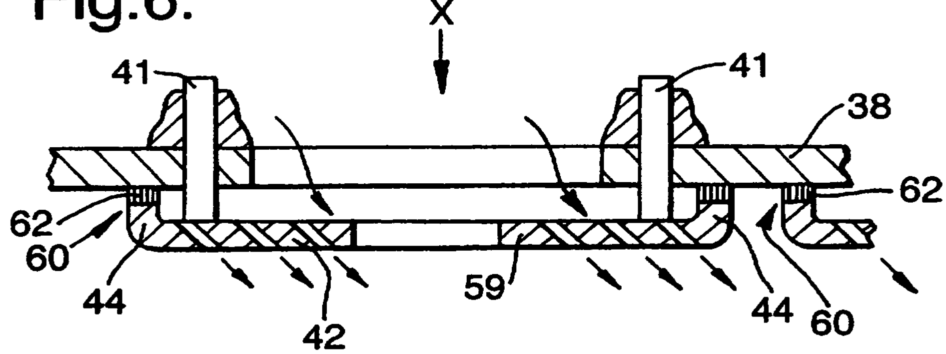


Fig.7.

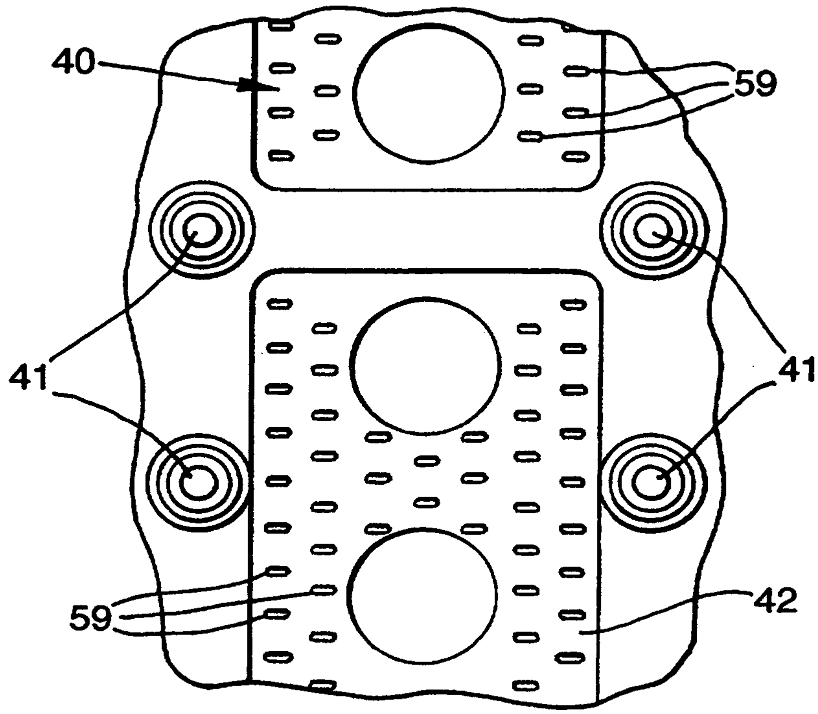


Fig.8.

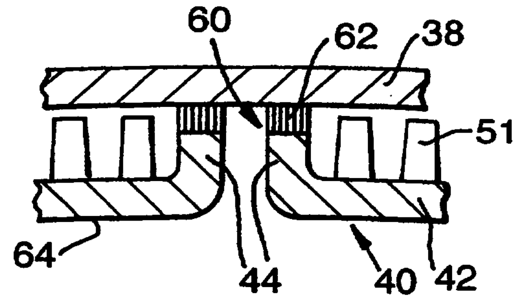


Fig.9.

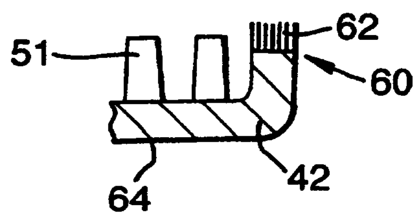


Fig.10.

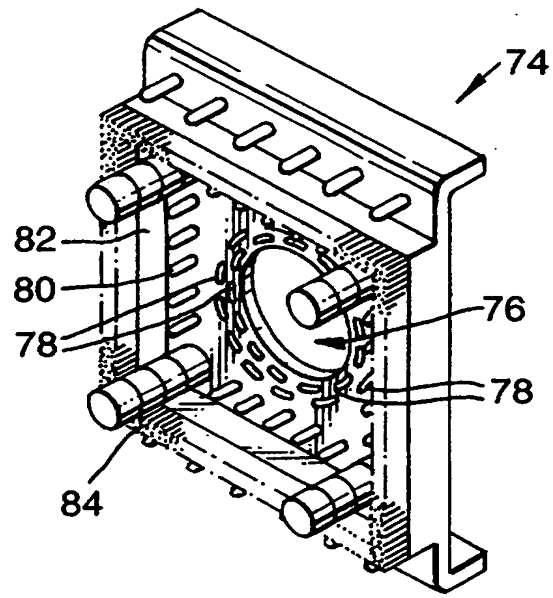
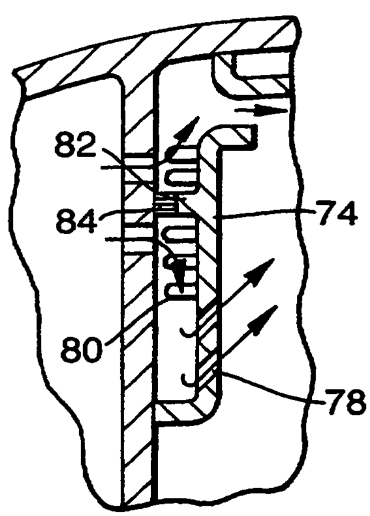


Fig.11.



COMBUSTION APPARATUS

The invention relates to a combustion apparatus for a gas turbine engine. More particularly the invention relates to a wall element for use in a wall structure of such a combustion apparatus.

A typical gas turbine engine combustor includes a generally annular chamber having a plurality of fuel injectors at an upstream head end. Combustion air is provided through the head and in addition through primary and intermediate mixing ports provided in the combustor walls, downstream of the fuel injectors.

In order to improve the thrust and fuel consumption of gas turbine engines, i.e. the thermal efficiency, it is necessary to use high compressor pressures and combustion temperatures. This results in the combustion chamber experiencing high temperatures and there is therefore a need to provide effective cooling of the combustion chamber walls. Various cooling methods have been proposed including the provision of a doubled walled combustion chamber whereby cooling air is directed into a gap between spaced outer and inner walls, thus cooling the inner wall. This air is then exhausted into the combustion chamber through apertures in the inner wall. The exhausted air forms a cooling film which flows along the hot, internal side of the inner wall, thus preventing the inner wall from overheating.

The inner wall may comprise a number of heat resistant tiles, such a construction being relatively simple and inexpensive. The tiles are generally rectangular in shape and are slightly curved to conform to the overall shape of the annular combustor wall. The tiles are conventionally longer in the circumferential direction of the combustor than in the axial direction.

Tiles may also be provided in a heatshield region of

the combustor, at its upstream end, around the fuel injectors.

The tiles are typically of cast construction, while the outer "cold" wall of the combustor wall structure is typically of sheet metal. Neither of these production methods produces components to very high tolerances and this inevitably results in gaps between adjacent tiles. It is also necessary to leave gaps between the edges of adjacent tiles, particularly the axially directed edges, in order to allow for expansion of the tiles in hot conditions. The air in the gap between the tiles and the outer cold wall is at a higher pressure than that inside the combustion chamber, and it is therefore inevitable that cooling air will leak into the combustion chamber through the axial gaps between adjacent circumferentially spaced tiles. The leaked air tends to form a relatively stiff, inwardly directed "wall" of air, which has a detrimental effect on the quality of the cool air film provided along the hot side of the tiles. As a result, overheating of the tiles may occur immediately downstream of the axial gap.

According to the invention there is provided a wall element for use as part of an inner wall of a gas turbine engine combustor wall structure including inner and outer walls defining a space therebetween, the wall element being provided with deformable seal means for sealing against the outer wall of the wall structure in use.

Preferably the seal means are arranged to be under deformation when the wall element forms part of the inner wall of the wall structure.

The seal means may be provided on or near one or more edges of the wall element.

Preferably the wall element includes a body portion and elongate edge portions projecting from the body portion, the seal means being provided on one or more edge portions.

Preferably the seal means includes a plurality of

crushable filaments. The crushable filaments may comprise a brush seal. The crushable filaments may be provided on one or more edge portions of the wall element and extend in use towards the outer wall of the wall structure.

Preferably the tile is of cast construction and the filaments are cast integrally with the tile.

The wall element may include a body portion provided with a plurality of projections which in use extend into the space between the inner and outer walls, the seal means protruding further from the body portion than do the projections.

The wall element may be generally rectangular and include axial and circumferential edges in use, the axial edges being generally orientated in an axial direction of the gas turbine engine combustor in use and the circumferential edges being generally orientated in a circumferential direction of the gas turbine engine combustor in use. Seal means may be provided on or near the axial edges of the wall element. Seal means may further or alternatively be provided on or near the circumferential edges of the wall element.

Alternatively the wall element may be for use in a backplate region of a combustor and may be generally sector shaped, including spaced radial edges and spaced circumferential edges. Seal means may be provided on or near the radial edges of the wall element. Seal means may further or alternatively be provided on or near the circumferential edges of the wall element.

According to the invention, there is further provided a wall structure for a gas turbine engine combustor, the wall structure including inner and outer walls defining a space therebetween, wherein the inner wall includes at least one wall element as defined in any of the preceding eight paragraphs.

The wall structure may include a plurality of wall elements, and edges of the wall elements may at least

partially overlap.

According to the invention there is further provided a wall structure for a gas turbine engine combustor, the wall structure including inner and outer walls defining a space therebetween, wherein the inner wall includes a plurality of wall elements and deformable seal means are provided between one or more wall elements and the outer wall of the wall structure. The seal means are preferably provided on a wall element, near one or more edges of the wall element.

The wall element may include edge portions which in use extend towards the outer wall of the wall structure and define a continuous wall generally around the periphery of the wall element, so that a discrete chamber is defined between the wall element and the outer wall, and the seal means may be provided on the edge portions.

According to the invention there is further provided a gas turbine engine combustion chamber including a wall structure as defined in either of the preceding two paragraphs.

According to the invention there is further provided a method of manufacturing a wall element for use as part of an inner wall of a gas turbine engine combustor wall structure including inner and outer walls defining a space therebetween, the method including the step of casting seal means in the form of a plurality of compressible filaments, integrally with the casting of the wall element.

An embodiment of the present invention will be described for the purpose of illustration only with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic diagram of a ducted fan gas turbine engine having an annular combustor;

Fig. 2 is a diagrammatic cross section of annular combustor;

Fig. 3 is a diagrammatic axial cross section of a wall structure of an annular combustor according to the prior art;

Fig. 4 is a partial diagrammatic cross sectional view along the arrow A of Fig. 3;

Fig. 5 is an enlarged diagrammatic partial view of Fig. 4;

Fig. 6 is a partial diagrammatic circumferential cross section through a combustor wall structure according to the invention;

Fig. 7 is a view in the direction of the arrow X in Fig. 6;

Fig. 8 is a diagrammatic circumferential cross section through the ends of two adjacent tiles according to the invention;

Fig. 9 is a diagrammatic sketch illustrating the assembly of a wall structure according to the invention;

Fig. 10 is a diagrammatic perspective view of a tile for use in a backplate region of a combustor; and

Fig. 11 is a partial section through the tile of Fig. 10, illustrating the air flow through the tile.

With reference to Fig. 1 a ducted fan gas turbine engine generally indicated at 10 comprises, in axial flow series, an air intake 12, a propulsive fan 14, an intermediate pressure compressor 16, a high pressure compressor 18, combustion equipment 20, a high pressure turbine 22, an intermediate pressure turbine 24, a low pressure turbine 26 and an exhaust nozzle 28.

The gas turbine engine 10 works in the conventional manner so that air entering the intake 12 is accelerated by the fan 14 to produce two air flows, a first air flow into the intermediate pressure compressor 16 and a second airflow which provides propulsive thrust. The intermediate pressure compressor 16 compresses the air flow directed into it before delivering the air to the high pressure compressor 18 where further compression takes place.

The compressed air exhausted from the high pressure compressor 18 is directed into the combustion equipment 20

where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through and thereby drive the high, intermediate and low pressure turbines 22, 24 and 26 respectively before being exhausted through the nozzle 28 to provide additional propulsive thrust. The high, intermediate and low pressure turbines 22, 24 and 26 respectively drive the high and intermediate pressure compressors 16 and 18 and the fan 14 by suitable interconnecting shafts (not shown).

The combustion equipment 20 includes an annular combustor 30 having radially inner and outer wall structures 32 and 34 respectively. Fuel is directed into the combustor 30 through a number of fuel nozzles (not shown) located at the upstream end of the combustor 30. The fuel nozzles are circumferentially spaced around the engine 10 and serve to spray fuel into air derived from the high pressure compressor 18. The resultant fuel and air mixture is then combusted within the combustor 30.

The combustion process which takes place within the combustor 30 naturally generates a large amount of heat. Temperatures within the combustor may be between 1,850K and 2,600K. It is necessary therefore to arrange that the inner and outer wall structures 32 and 34 are capable of withstanding these temperatures while functioning in a normal manner. The radially outer wall structure 34 can be seen more clearly in Fig. 2.

Referring to Fig. 2A the wall structure 34 includes an inner wall 36 and an outer wall 38. The inner wall 36 comprises a plurality of discrete tiles 40 which are all of substantially the same rectangular configuration and are positioned adjacent each other. The majority of the tiles 40 are arranged to be equidistant from the outer wall 38, and the tiles are arranged such that a downstream edge of each tile 40 overlaps an upstream edge of an adjacent tile 40. Each tile 40 is of cast construction and is provided with integral studs 41 which facilitate its attachment to

the outer wall 38.

The pressure of the air in a feed annulus defined between the outer wall 38 and combustor casing 39 is about 3% to 5% higher than the pressure within the combustor 30 (perhaps 600 psi as opposed to 570 psi). The air temperature outside the combustor 30 is about 800K to 900K. Feed holes (not shown in Fig. 2A) are provided in the outer wall 38 such that high pressure, relatively cool air flows into a space 50 between the tiles 40 and the outer wall 38. Effusion holes (not shown in Fig. 2A) are provided within the tiles 40 such that the cooling air flows through the tiles 40 and forms a cool air film over the hot, internal surface of the tiles 40. This air film prevents the tiles 40 from overheating.

The cooling film flows over the tiles 40 in the general direction of fluid flow through the combustor 30, i.e. to the right as shown in Figs. 2A and 2B.

Fig. 2B illustrates an alternative arrangement of tiles 40 in a combustor wall structure 32, 34. The arrangement is generally similar to that of Fig. 2A, and the same reference numerals are used for equivalent parts. However, instead of the tiles 40 being in overlapping relationship, they lie generally in the same plane. Fig. 2B also illustrates a tile 74 provided in a backplate region 54 of the combustor 30. This is described in more detail below.

The tiles 40 may be provided with continuous walls or sealing rails 44 therearound, such that a discrete space 50 is defined between each tile 40 and the outer wall 38. This arrangement is described in European Patent No. 576435B, and is advantageous in that it typically results in a relatively high pressure drop across the tile and through the effusion holes.

Figs. 3 to 5 illustrate a wall structure 32, 34 of a prior art combustor 30, the tiles being in the overlapping relationship of Fig. 2A. However the tiles 40 could

alternatively be arranged as in Fig. 2B.

Referring to Figs. 4 and 5, the tiles 40 may be provided with upstanding pedestals 51, which extend into the space 50. The air within the space 50 flows over and around the pedestals 51, this further helping to cool the tiles 40 and prevent overheating.

Referring to Figs. 3 to 5, each tile 40 includes a main body portion 42 which is shaped to conform to the general shape of the combustor wall structure 32, 34. At an axially directed edge of each tile, a sealing rail 44 extends from the main body portion 42 of the tile towards the outer wall 38. The sealing rails 44 are intended to minimise the leakage of air from the space 50, around the edges of the tiles 40, and into the combustor 30. However, due to manufacturing tolerances, there is a small gap 46 between the sealing rail 44 of each tile 40 and the outer wall 38. Adjacent sealing rails 44 of adjacent tiles 40 are located a small distance apart, resulting in an axial gap 48.

Because the pressure within the space 50 between the tiles 40 and the outer wall 38 is higher than the pressure within the combustor 30, air leaks from this space 50 through the gaps 46 and 48 into the combustor 30. A substantially planar "wall" of leakage air forms inwardly of the axial gap 48. This wall of air disrupts the cooling air film provided on the inner hot side of the tiles 40. The film is particularly disruptive in a region just downstream of the axial gap 48 and overheating may occur in this region.

According to prior art designs, it is typical for 20% to 25% of the combustor wall structure pressure drop available to occur across the tiles 40, with the remaining 75% to 80% occurring across the outer wall 38. This is at least partly because a greater pressure drop across the tile 40 would result in more uncontrolled leakage. In general, it is advantageous to increase the pressure drop

across the tile 40, because this can increase the quality of the cooling air film and also produce increased convective heat removal (possibly via pedestals on the tiles). However, increasing this pressure drop is most advantageous if the high pressure air is forced through the effusion holes (see Fig. 6) in the tiles, to form a coherent air film. If the higher pressures result in more leakage around the edges of the tiles 40, the cooling air film is damaged and overheating may occur.

Referring to Figs. 6 to 8, a tile 40 according to the invention includes a main body portion 42 provided with angled effusion holes 59. The tile 40 includes sealing rails 44 along its axial and circumferential edges, and the sealing rails are provided with brush seals 60 which extend from the sealing rails 44 away from the main body portion 42. The brush seals 60 consist of thin filaments 62 of metal/metal alloy which may be cast integrally with the remainder of the tile 40. The filaments 62 of metal are designed such that they are pushed against the outer wall 38 when the tile 40 is attached to the outer wall 38 via studs 41. This causes the brush seals to distort and to provide a seal between the sealing rails 44 of the tiles 40 and the outer wall 38.

Fig. 9 illustrates the lengths of the filaments 62 in their undistorted condition; it will be seen that the filaments 62 of the brush seals 60 are designed such that they must be crushed or flexed in order to secure the tile into place against the outer wall 38. In the example shown in Fig. 9 and also Fig. 8 pedestals 51 are incorporated to enhance convective heat removal, but alternative convective means such as angled holes, or a combination of alternative means, may be provided.

The crushed or flexed filaments 62 fill the gaps 46 between the tile sealing rails 44 and the outer wall 38.

The seals 60 therefore minimise the amount of leakage which is able to occur from the edges of tiles 40, thus

resulting in a controlled air film along the inner faces 64 of the tiles 40. This minimises the risk of overheating of the combustion chamber wall. The seals also allow an increased pressure drop to occur across the tile 40, this resulting in an enhanced cooling air film on the hot side of the tiles 40 and enhanced convective heat removal from the cold-side of the tiles 40.

Referring to Fig. 2B and to Figs. 10 and 11, the invention is also applicable to heatshield tiles 74 for use in the backplate region 54 of the combustor 30 (see Fig. 2B). Each heatshield tile 74 is provided around a burner (not shown) and includes an orifice 76 (see Fig. 10) for allowing fuel to enter the combustor 30. The heatshield tiles 74 are sector shaped, and a plurality of the heatshield tiles 74 are arranged to form a heatshield at the upstream end of the annular combustor 30.

Each heatshield tile 74 is provided with angled cooling orifices 78, for enabling cooling air to flow through the heatshield tiles 74 as illustrated in Fig. 11. The heatshield tiles 74 may also be provided with pedestals 80 for improving cooling, as described previously in relation to the tiles 40.

Referring to Fig. 10, each heatshield tile 74 is provided with a sealing rail 82 generally around its perimeter. Brush seals 84 may be provided on all or part of the sealing rail 82, in a similar manner to that described for the tiles 40. The seals 60 minimise the amount of leakage around the edges of the tiles 74, resulting in enhanced cooling.

Various modifications may be made to the above described embodiments without departing from the scope of the invention. The brush seals 60 may be provided on any or all of the edges of the tiles 40, 74. Instead of being cast integrally with, and from the same material as, the remainder of the tiles 40, 74, the filaments 62 may initially be formed separately. The filaments 62 may then

be attached to the remainder of the tiles 40, 74 during the casting process. Alternatively, the brush seal filaments 62 may be brazed or attached in any other way to the sealing rails 82 of the tiles 40.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. A wall element for use as part of an inner wall of a gas turbine engine combustor wall structure including inner and outer walls defining a space therebetween, the wall element being provided with deformable seal means for sealing against the outer wall of the wall structure in use.

2. A wall element according to claim 1 wherein the seal means are arranged to be under deformation when the wall element forms part of the inner wall of the wall structure.

3. A wall element according to claim 1 or claim 2 wherein the seal means are provided on or near one or more edges of the wall element.

4. A wall element according to claim 3 wherein the wall element includes a body portion and elongate edge portions projecting from the body portion and wherein the seal means are provided on one or more of said edge portions.

5. A wall element according to any preceding claim wherein the seal means includes a plurality of crushable filaments.

6. A wall element according to claim 5 wherein the crushable filaments comprise a brush seal.

7. A wall element according to either of claim 5 or claim 6 when appended to claim 4 wherein the crushable filaments are provided on one or more edge portions of the wall element and extend in use towards the outer wall of the wall structure.

8. A wall element according to any of claims 5 to 7 wherein the tile is of cast construction and the filaments are cast integrally with the tile.

9. A wall element according to any preceding claim, the wall element including a body portion provided with a plurality of projections which in use extend into the space between the inner and outer walls, wherein the seal means protrudes further from the body portion than do the

projections.

10. A wall element according to any preceding claim wherein the wall element is generally rectangular and includes axial and circumferential edges, the axial edges being generally oriented in an axial direction of the gas turbine engine combustor in use and the circumferential edges being generally oriented in a circumferential direction of the gas turbine engine combustor in use.

11. A wall element according to claim 10 wherein seal means are provided on or near the axial edges of the wall element.

12. A wall element according to claim 11, wherein seal means are provided also on or near the circumferential edges of the wall element.

13. A wall element according to any of claims 1 to 9, the wall element being for use in a backplate region of a combustor.

14. A wall element according to claim 13, the wall element being generally sector shaped, including spaced radial edges and spaced circumferential edges.

15. A wall element according to claim 14 wherein seal means are provided on or near the radial and/or the circumferential edges of the wall element.

16. A wall element substantially as herein described with reference to Figs. 5 to 9 of the drawings.

17. A wall element substantially as herein described with reference to Figs. 10 and 11 of the drawings.

18. A wall structure for a gas turbine engine combustor, the wall structure including inner and outer walls defining a space therebetween, wherein the inner wall includes at least one wall element according to any preceding claim.

19. A wall structure according to claim 18, wherein the wall structure includes a plurality of wall elements, and edges of the wall elements at least partially overlap.

20. A wall structure for a gas turbine engine combustor, the wall structure including inner and outer walls defining

a space therebetween, wherein the inner wall includes a plurality of wall elements and deformable seal means are provided between one or more wall elements and the outer wall of the wall structure.

21. A wall structure according to claim 20 wherein the seal means are provided on a wall element, on or near one or more edges of the wall element.

22. A wall structure according to claim 21 wherein the wall element includes edge portions which in use extend towards the outer wall of the wall structure and define a continuous wall generally around a periphery of the wall element, so that a discrete space is defined between the wall element and the outer wall, and wherein the seal means are provided on the edge portions.

23. A wall structure substantially as herein described with reference to Figs. 6 to 9 of the drawings.

24. A wall structure substantially as herein described with reference to Figs. 10 and 11 of the drawings.

25. A gas turbine engine combustion chamber including a wall structure according to any of claims 18 to 24.

26. A method of manufacturing a wall element for use as part of an inner wall of a gas turbine engine combustor wall structure including inner and outer walls defining a space therebetween, the method including the step of casting seal means in the form of a plurality of compressible filaments, integrally with casting of the wall element.

27. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

Application No:	GB 0009237.9	**Examiner:**	Paul Jenkins
Claims searched:	1-26	**Date of search:**	28 September 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F4T (TAR3, TAR4, TAR5)

Int Cl (Ed.7): F23R 3/00, 3/60

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO 98/16764 A1	(WESTINGHOUSE) Whole document relevant, see especially figures 2A & 2B	1-7
X	US 5913678	(HÖCKER) Whole document relevant	1-4, 10-12 & 18-21
A	US 5799491	(BELL) Column 6 lines 5-12 and figure 5a	-------

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.